Cornell University

Department of Physics

Physics 7652 January 25, 2024

Spring 2024
Relativistic Quantum Field Theory II

Course Information

> *The Lord said:* This body, O son of Kunti, is called the Field, and he who knows it is called the Knower of the Field by those who describe him.
>
> And know that I am the Knower in all Fields, O Bharata; and only the knowledge of the Field and its Knower do I regard as true knowledge.
>
> Hear briefly from Me what the Field is, what its nature is, what its modifications are, whence it comes, who its Knower is, and what His powers are.
>
> – *The Bhagavad Gita*, ch. XIII, v. 1–3, translated from the Sanskrit by Swami Nikhilananda.

Abstract: Physics 7652 is the 2nd semester of the Relativistic QFT sequence. Major topics covered include: path integral approach to QFT, renormalization group, non-abelian gauge theories, spontaneous breaking of global and gauge symmetries, and anomalies. This course introduces basic concepts and tools required for research in theoretical particle physics and string theory, and is required for LEPP theory group students. It may also be of interest to students in condensed matter theory, theoretical cosmology, and particle experiment.

Prerequisites: Physics 7651 (Relativistic QFT I); plus all prerequisites for that class.

Lecturer: Maxim Perelstein, PSB 471, x5-5151 (`mp325@cornell.edu`);

Office hours: Wednesdays 4-5 pm. (Professor will also be available for discussion after lectures, Tue/Thu 11:30 pm $\sim$ 12 noon, in the lecture room.)

Grader: Lillian Luo, `yl823@cornell.edu`

Class Times and Locations:
Lectures Tue/Thu 10:10-11:25 am, Clark 294 G.

Course Web Page: Canvas

Textbooks: We will not follow a single textbook. Lecture notes will be provided. Recommended textbooks include:

- *Quantum Field Theory*, by M. Srednicki.
- *An Introduction to Quantum Field Theory*, by M. Peskin and D. Schroeder.
- *Quantum Field Theory and the Standard Model*, by M. Schwartz.
- *Quantum Field Theory in a Nutshell*, by A. Zee.
- *The Quantum Theory of Fields*, by S. Weinberg.

Homework: There will be approximately one problem set every two weeks. The problem sets will be posted on Canvas. Each student in the course is expected to abide by the Cornell University Code of Academic Integrity.

Final Exam: There will be a take-home final exam (24 hrs.) at the end of the course. There will be no prelims/midterms.

Course Grades: The course grade will be based on homework (60%) and final exam (40%). If S/U option is chosen, the S grade requires at least 50% of the total credit. Audit (A) option is available; no homework or exams are required for auditors, but attendance at at least 75% of lectures is expected.

Tentative Syllabus

- *Functional Integrals:* Path integrals in Quantum Mechanics and QFT. Functional quantization of scalar and fermion fields. Connection between quantum field theory and statistical mechanics. Quantization of abelian gauge fields. The Ward-Takahashi identity.
- *Quantum Electrodynamics II:* Renormalized perturbation theory and counterterms in QED. Renormalization group and running coupling constant. Infrared divergences.
- *Non-Abelian Gauge Theories:* Lie algebras and representations. Geometry of gauge invariance. Yang-Mills Lagrangian. Quantization of non-abelian gauge theories. Faddeev-Popov ghosts. Renormalization group and asymptotic freedom.
- *Theories with Broken Symmetries:* Spontaneous breaking of global symmetries and Goldstone's theorem. Chiral perturbation theory and effective field theories. Spontaneous breaking of gauge symmetries: Higgs mechanism. Quantization of spontaneously broken gauge theories and R_ξ gauges. Theory of electroweak interactions and the Standard Model.
- *Anomalies.*